LQ search in eejj channel (preliminary status report)

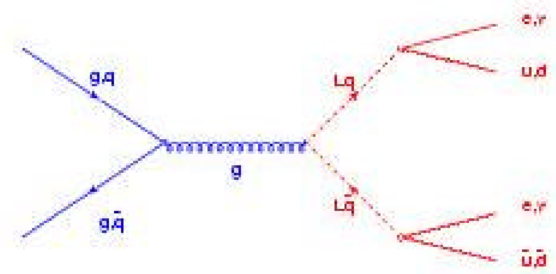
Simona Rolli (TUFTS)
Andrej Rosano (Trieste)

Introduction

- Some beyond the SM models assume additional symmetry between leptons and quarks
- LeptoQuarks – transition between leptons and quarks
  - Have both lepton and baryon numbers
  - λ - unknown coupling to leptons and quarks

LQ at the TeVatron

- Production
  - qg $\rightarrow$ LQ + LQbar
  - gg $\rightarrow$ LQ + LQbar
  - qqbar $\rightarrow$ LQ + Lqbar



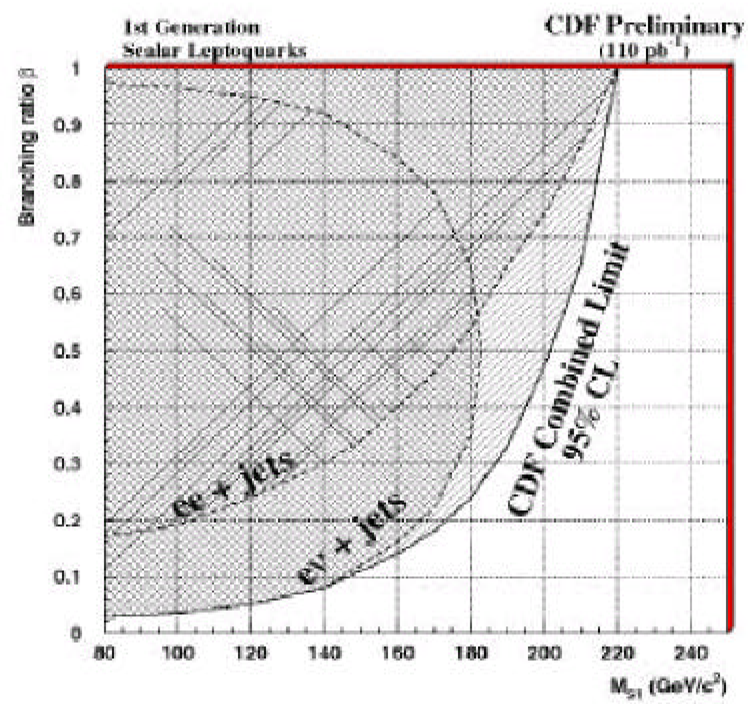
- Decay
  - LQ $\rightarrow$ l^+l^-qq, $l^\pm\nu$qq, $\nu\nu$qq
- Experimental signature:
  - High pt isolated leptons (and/or MET) + jets

Tevatron Leptoquark Limits

- Limits depend on type of LQ (scalar/vector, generation), LQ-q-l couplings and β=BR(LQ $\rightarrow$ $l^{\pm}q$)

1st generation LQ mass limits

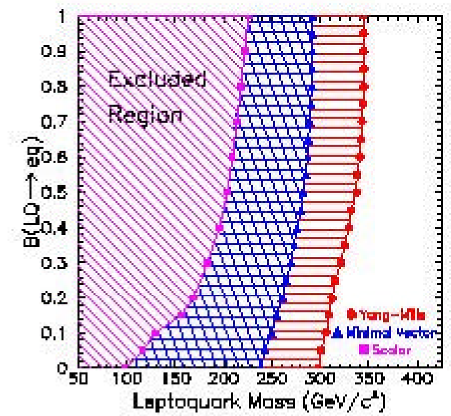
1st Gen.	β	Scalar (GeV/c)	Vector Minimal Coupling (GeV/c)	Vector Yang-Mills Coupling (GeV/c)
DZero	1	225(242)	292	345
	0.5	204	282	337
	0	98	238	298
CDF	1	220(242)	280	330
	0.5	202	265	310

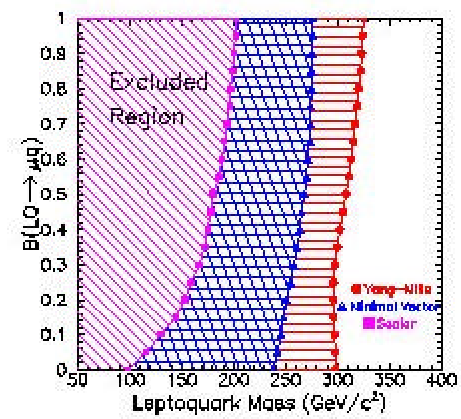


Tevatron Leptoquark Limits

2nd Gen	β	Scalar (GeV/c)	Vector Minimal Coupling (GeV/c)	Vector Yang-Mills Coupling (GeV/c)
DZero	1	200	275	325
	0.5	180	260	310
	0	98	238	298
CDF	1	202		
	0	123	171	222

3rd Gen	β	Scalar (GeV/c)	Vector Minimal Coupling (GeV/c)	Vector Yang-Mills Coupling (GeV/c)
DZero	0.5			209
	0	98	238	298
CDF	1	99	170	225
	0	148	199	250





This analysis

- Will start with eejj channel
  - High pt ele dataset used already for DY analysis
  - + Jets requirement
    - 2 isolated electrons
      - One tight (central)
      - One loose (central or plug)
    - At least 2 energetic jets
  - Will follow Federica Strumia's analysis
    - Not trying to change cuts now, trying to reproduce her numbers

This analysis

- MC study
  - Signal
    - Ele id efficiency
    - Analysis cuts efficiency
  - Background
    - ttbar with W decay to $l\nu$
    - DrellYan with radiative jets from ISR

Tools

- Signal generated and reprocessed with 4.8.2
  - 1000 events at masses from 200 to 320
- eN (4.8.2)used for ntuple analysis
  - http://ncdf70.fnal.gov:8001/talks/eN/eN.html

Electron ID

- At least on central ele
  - $E_t \geq 20$ GeV ($|\eta| < 1.5$)
  - hadem <= 0.055
  - E/p < 1.8
  - iso4e/emet < 0.1
  - |Dx| < 1.5
  - |Dz|) < 3.0
  - lshr <= 0.2
  - |chi2s|< 10
  - |vtx_zv - el_zv| < 5
  - |el_zv| < 60
  - Conversion removal
  - Fiducial > 0

CUT	Tight (Central)	Loose (Central / Plug)
Had/Em	< 0.05	< 0.1
E/p	< 1.8	< 4.0 / *none*
Isolation	< 0.1	< 0.1
$\|\Delta x\|$	≤ 1.5 cm	*none*
$\|\Delta z\|$	≤ 3.0 cm	*none*
$Lshr$	< 0.2	*none*
χ^2_{str}	< 10.0	*none*
$\chi^2_{3\times3}$	*none*	≤ 3.0
$\|Z_v - Z_e\|$	≤ 5.0 cm	*none*
$\|Z_v\|$	≤ 60.0 cm	*none*
Conversion	yes	yes
Fiducial	yes	*none*

Second Loose ele

- $E_t \geq 15$ GeV
- Isolation
- E/p < 4

eN electron

- In eN the information from cdfEmObject is replicated at 3 levels:
- 1.EM cluster + EM object info + trkid and charge (not zero for electron)
- 2.Cluster Seed + CES strip/wire + hadronic component + track info
- 3.PES (the PES2d cluster, matched to the highest Pt track if it exists, is accepted if DR&lt0.25 respect the extrapolated track. If no track, the PES 2d cluster is accepted if it is contained in any PEM tower associated with the EmCluster.)

Switched on levels 1 and 2

eN electron variables used

- Emet [nele] emEt() cluster e.m. Et in GeV
- tote [nele] totalEnergy() total (had+em) cluster Energy
- totet [nele] totalEt() total (had+em) cluster Et using default Z vertex
- hadem [nele] hadEm() cluster E(had)/E(em) using all towers in the cluster.
- iso4e [nele] totalIsolationEt4() cluster had + em excess Et(GeV) in DR=0.4
  - Isolation = iso4e/emet
- lshr [nele] lshrTrack or lshrUnbiased if no track (old lshr(3)) CEM only!
- trkDx [nele] xdiff() matching difference between x(trk at CES) and x(CES)
- trkDz [nele] zdiff() matching difference between z(trk at CES) and z(CES)
- fiducial [nele] how fiducial is this electron following fidEle()
- chi2s [nele] CES chi2 strips corrected with E(em) of the CEM corrected object

Federica's analysis

N_{passed}/N_{total}

M_{S1}(GeV/c^2)	ε_e "eνjj"	M_{S1}(GeV/c^2)	ε_{ee} "eejj"
140	$(72.2 \pm 2.2)\%$	**100**	$(65.9 \pm 1.9)\%$
150	$(72.0 \pm 2.1)\%$	**120**	$(65.2 \pm 1.8)\%$
160	$(72.0 \pm 2.1)\%$	**140**	$(63.7 \pm 1.7)\%$
170	$(70.9 \pm 2.1)\%$	**160**	$(60.3 \pm 1.6)\%$
180	$(69.7 \pm 2.0)\%$	**180**	$(62.9 \pm 1.7)\%$
190	$(70.1 \pm 2.1)\%$	**200**	$(60.8 \pm 1.6)\%$
200	$(67.7 \pm 2.0)\%$	**220**	$(60.3 \pm 1.6)\%$
210	$(69.7 \pm 2.0)\%$	**240**	$(58.5 \pm 1.5)\%$

Table 4.2: *Electron-identification efficiencies evaluated on Monte Carlo leptoquark events for the two analyses in the scalar case.*

N_{total} :evts with 2 central ele with 40-15,matching the generated ele

N_{passed}: evts with one ele passing the tight and one ele passing the loose id cuts

M_{S1}(GeV/c^2)	180	200	220	240
$E_{T_e} > 40$, 15 GeV	$(82.9 \pm 1.6)\%$	$(86.0 \pm 1.6)\%$	$(87.8 \pm 1.6)\%$	$(88.7 \pm 1.7)\%$
$\geq$2 jets	$(65.3 \pm 1.3)\%$	$(66.4 \pm 1.3)\%$	$(68.2 \pm 1.4)\%$	$(68.3 \pm 1.4)\%$
M_{ee} cut	$(57.0 \pm 1.2)\%$	$(58.6 \pm 1.2)\%$	$(61.6 \pm 1.3)\%$	$(62.7 \pm 1.3)\%$
$\sum E_{T's} > 85$ GeV	$(51.5 \pm 1.1)\%$	$(54.5 \pm 1.2)\%$	$(57.8 \pm 1.2)\%$	$(59.8 \pm 1.3)\%$
$\sqrt{\sum E_{T's}^2} > 200$ GeV	$(46.9 \pm 1.1)\%$	$(52.0 \pm 1.1)\%$	$(56.3 \pm 1.2)\%$	$(58.5 \pm 1.2)\%$
ε_{ID}^{el}	$(29.6 \pm 0.8)\%$	$(31.8 \pm 0.8)\%$	$(34.6 \pm 0.9)\%$	$(34.2 \pm 0.9)\%$

Table 5.8: *The efficiency of each kinematical cut applied in the selection, and the total efficiency after the electron-ID cuts for different values of* M_{S1}. *The errors on the efficiencies are only statistical.*

Ele id E_{passed}/ E_{tot} (#evts with at least 2 ele, 40, 15)

m_{LQ} = 200	m_{LQ} = 220	m_{LQ} = 240	m_{LQ} = 260
56.1% (60.8 ±1.6)	55.7% (60.3 ±1.6)	55.7% (58.5 ±1.5)	53.4%
m_{LQ} = 280	m_{LQ} = 300	m_{LQ} = 320	m_{LQ} = 340
53.6%	53.5%	54.6%	

Analysis cuts

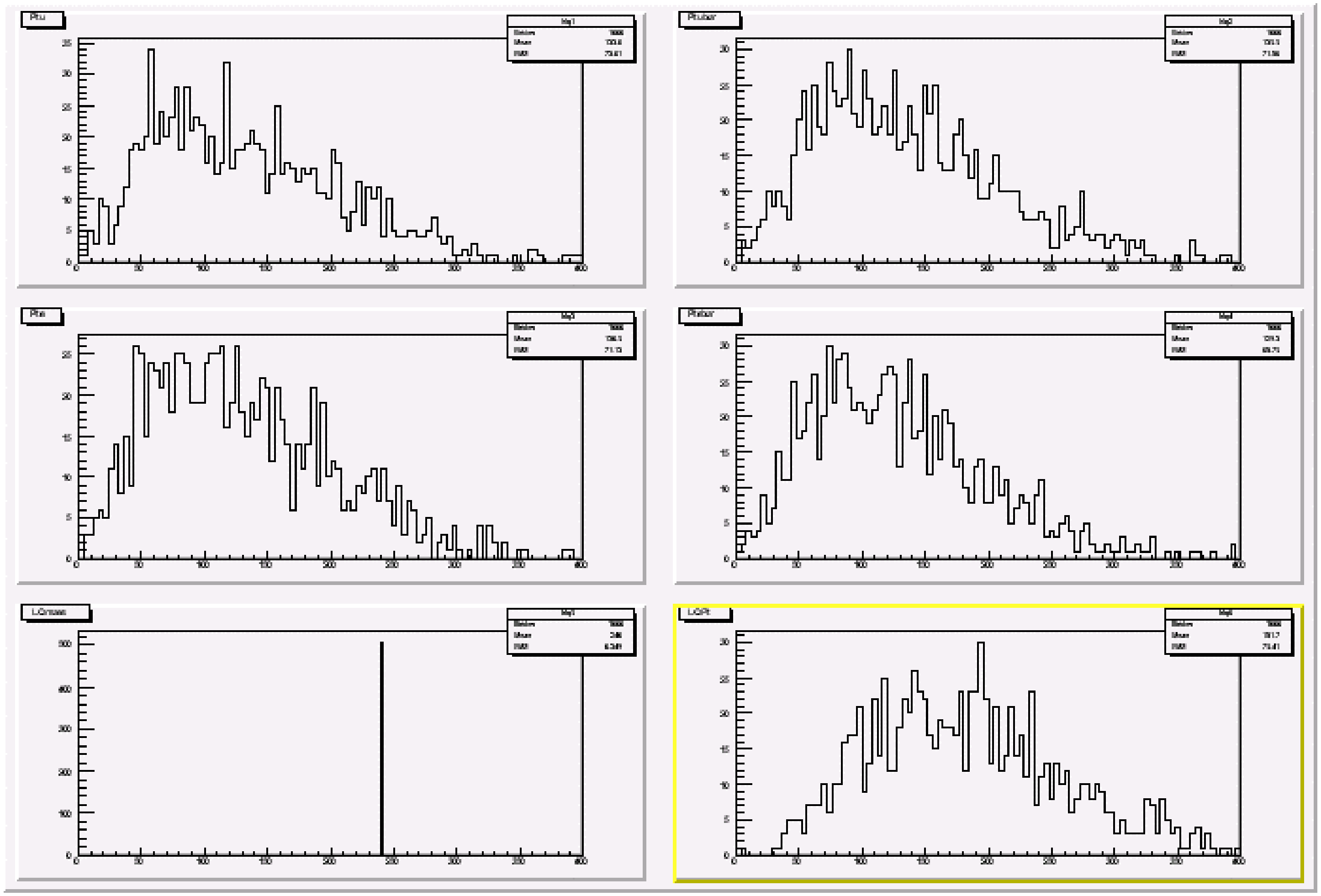
M_{S1}	200	220	240	260	280
$E_{te} \geq 40$, 15 GeV	71.0%	71.8%	72.5%	75.9%	73.6%
≥ 2 jets	66.8%	66.5%	68.5%	71.1%	68.9%
M_{ee} cut	56.5%	54.6%	58.1%	59.9%	59.2%
$\Sigma E_{T's} \geq 85$ GeV	49.1%	49.8%	54.0%	56.9%	56.1%
$\sqrt{\Sigma E_{T's}{}^2} \geq 200$ GeV	46.4%	48.2%	53.4%	56.4%	55.7%
el_{ID}	26.03%	26.84%	29.74%	30.1%	29.8%

Ele id efficiency

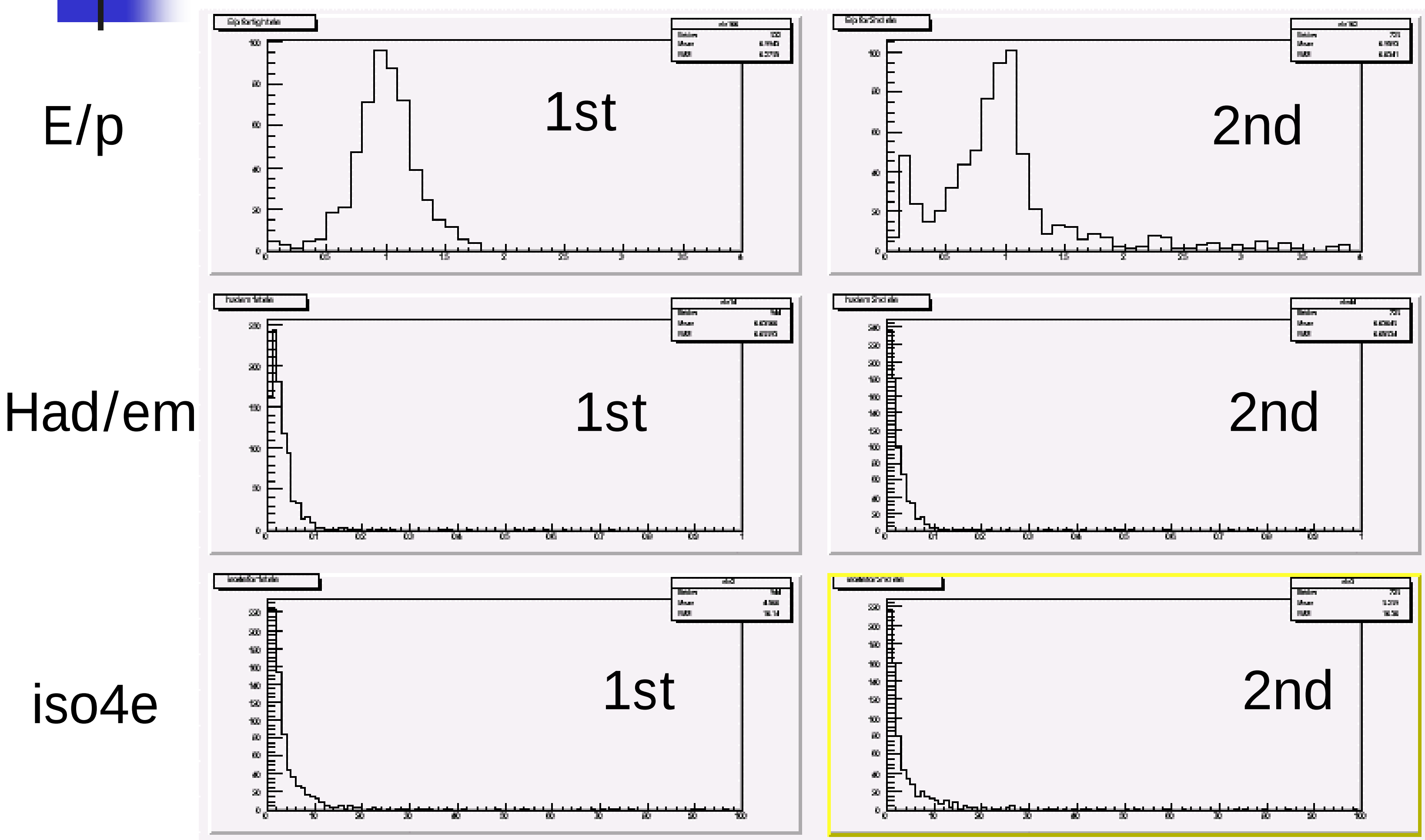
- From data, the dielectron id efficiency were done by combining the individual efficiencies for tight-loose fiducial, tight-loose non fiducial and tight-plug where A,B,C are the proportions evaluated on MC samples of LQ for different masses, in which are present these 3 kinds of categories on the events.

$$\varepsilon_{ee} = A \times \varepsilon_{tlf} + B \times \varepsilon_{tlnf} + C \times \varepsilon_{tlp}$$

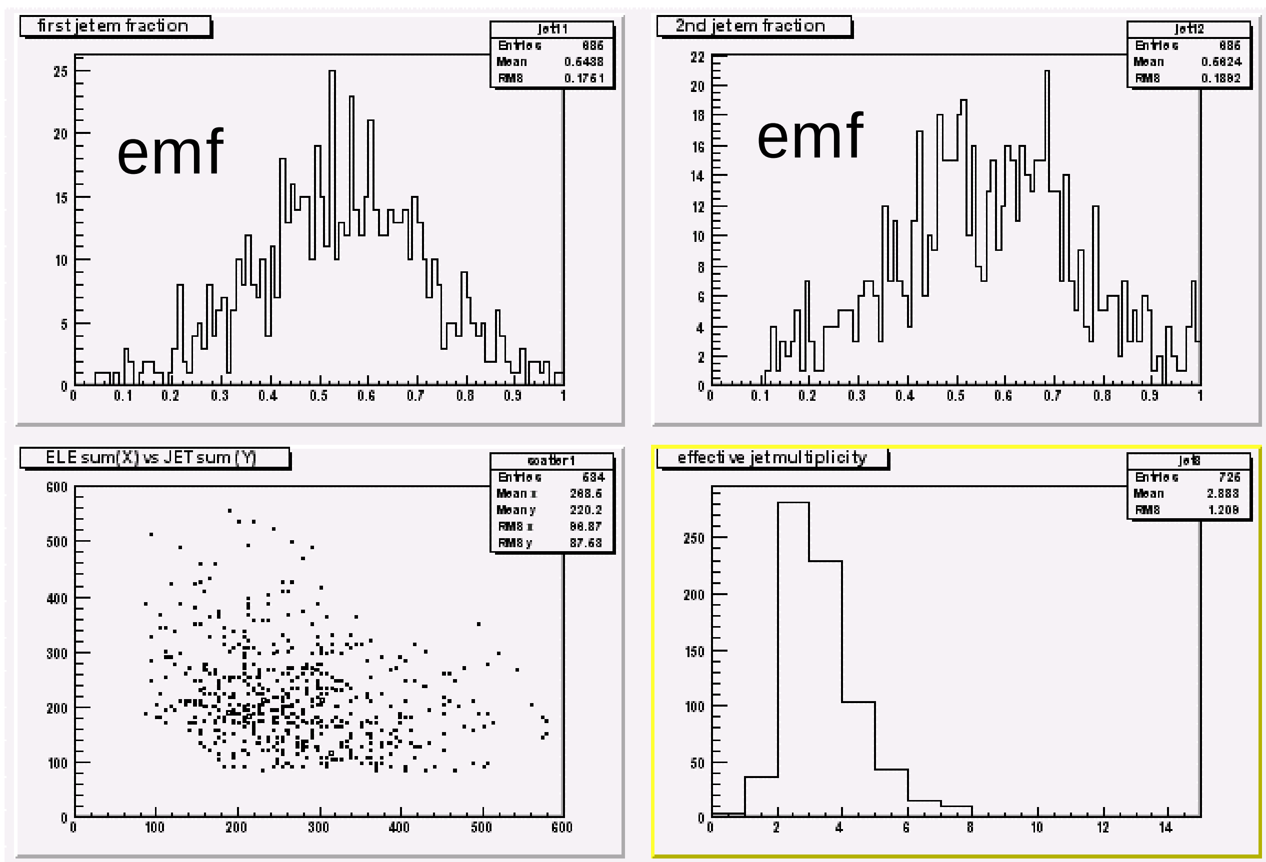
HEPG (LQ_m = 240)



Electrons (LQ_m = 240)



jets (LQ_m = 240)


first jet em fraction
jeti1
Entries 686
Mean 0.6438
RMS 0.1761
emf
2nd jet em fraction
jeti2
Entries 686
Mean 0.6624
RMS 0.1862
emf
ELE sum(X) vs JET sum(Y)
scatter1
Entries 634
Mean x 268.6
Mean y 220.2
RMS x 96.87
RMS y 87.63
effective jet multiplicity
jet3
Entries 726
Mean 2.883
RMS 1.209

First look at bckg

- DY + jet
  - Generated 5000 evts
    - evt with 2 ele - 40 15 = 1407
    - evt with 2 ele - 40 15 and >= 2 jets = 721
    - evt with 2 ele - 40 15 and >= 2 jets = and M_ee cut = 699
    - evt with 2 ele - 40 15 and >= 2 jets = and M_ee cut and 2jet_85 = 24
    - evt with 2 ele - 40 15 and >= 2 jets = and M_ee cut and 2jet_85 and sumet cut = 3

First look at bckg

- Top, 500 evts

- evt with 2 ele - 40 15 = 201
- evt with 2 ele - 40 15 and >= 2 jets = 174
- evt with 2 ele - 40 15 and >= 2 jets = and M_ee cut = 131
- evt with 2 ele - 40 15 and >= 2 jets = and M_ee cut and 2jet_85 = 42
- evt with 2 ele - 40 15 and >= 2 jets = and M_ee cut and 2jet_85 and sumet cut = 16

Plans

- Reprocess high et ele dataset with 4.8.4
  - Electron_central_18 & Electron_70
- Add jet selection
  - Jet corrections
- Check ele id with W mass analysis cuts
- Background studies
- .....
- limit